Frequency Analysis of Transactions in Local Payment system

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Abstract. The goal of experimental economics study is frequency analysis of transactions between local community agents. Agents are students at their project training. All transactions for goods and services were in points (local financial instrument) and took place in the local educational payment system. In the interval of 2 – 50 days the most significant were transactions with periodicity of 6 – 7 and 12 days. Such periodicity reflects the week cycles of human activity in studies as well as in goods and services consumption.

Keywords: Experimental economics, Autonomous local community, Local financial instruments, Local payment system, Project training, Students' activity, Human – computer interaction, Fourier frequency analysis, Numerical analysis, Data set.

Introduction

The study of the patterns of harmonization interaction between institutions of self-government by local finance and financial federalism requires besides theoretical, also experimental studies. In this paper, the experimental economics model of local community, created on the basis of a students' group during project training, is studied. The aim of experimental economics research is frequency analysis of transactions between local community agents, namely students at their project training.

On the basis of Department of Systems Analysis and Decision Making Graduate School of Economics and Management Ural Federal University apply the experimental educational payment system (EPS) for passing by student's project training. Within this experiment created social – economic system reflecting interaction of real agents.

Managing of students' project training requires regular control. Information technology is becoming an integral part of the educational process, as it provides advantages such as speed of processing results, objectivity, mass, as well as a significant reduction in the time spent by the teacher in the individual control, which improves the quality of the educational process [1].

Educational payment system is an electronic noncommercial platform for students' exchange of goods and services of its own production by points (local financial instrument). Relations between the participants of the system are based on the construction of communications within the framework of projects. Students run the tasks received by teacher during the semester, and their actions reflected in the database of the EPC, which makes it possible to control the intensity of work and involvement of students in the educational process [2].

1 Work of the system

This project allows students to get acquainted with the practical economy, to try themselves as an entrepreneur, using various methods to promote their product or service. The educational process was organized in accordance with the basic principles of Agile methodology, which is the main tool for the formation of professional communication within the project groups and adaptation of students to the working processes.

High level of interaction ensures the continuity of the educational process beyond the classroom. The clarity of the ideology and interface of socio – economic networks for Internet audience saves time, letting to avoid the stage of students' adaptation to the new communicative space [3].

Using the educational payment system in the educational process is aimed at improving the control over the regularity of training by the teacher. In this scientific article discusses the concept of implementing a module to display the personal activity of each student. This tool is a timing diagram of the user's actions in the system, built on the basis of information from the EPS database received from the developers of the system. The necessary data are the products placed in the catalog, the list of users of the system and the calculations made between users. This allows you to assess the regularity of assignments during the semester, which clearly shows the teacher the student's work throughout the period of study.

Figure 1 (Fig.1) shows the activity of individual students during a particular stage of the learning process. The red and blue colors indicate the number of purchase and sale actions performed by the user, respectively. The schedule is divided into weeks, as the educational process has a cycle of 7 days. Different colors reflect the processes of "buy" and "sell", the nodes of the graph reflect the number of interactions on certain dates. The analysis of work in educational payment system was carried out in the period from 27.02.2018 to 17.04.2018 until the receipt of the task for students to work in groups. This will assess the independent work of students. Four most illustrative examples with different degrees of activity were identified.

As we can see at Figure 1, the activity of students on the timeline is different. Some remain active throughout the learning process, while others increase activity at the beginning or end of the semester. This analysis will allow teacher to estimate the

independent work of the student appropriately. Another convenient tool for assessing the effectiveness of training can be a general graph of the academic group's activity in time. The results of the analysis the work flow for training period from 27.02.2018 to 17.04.2018 are shown in figure 2

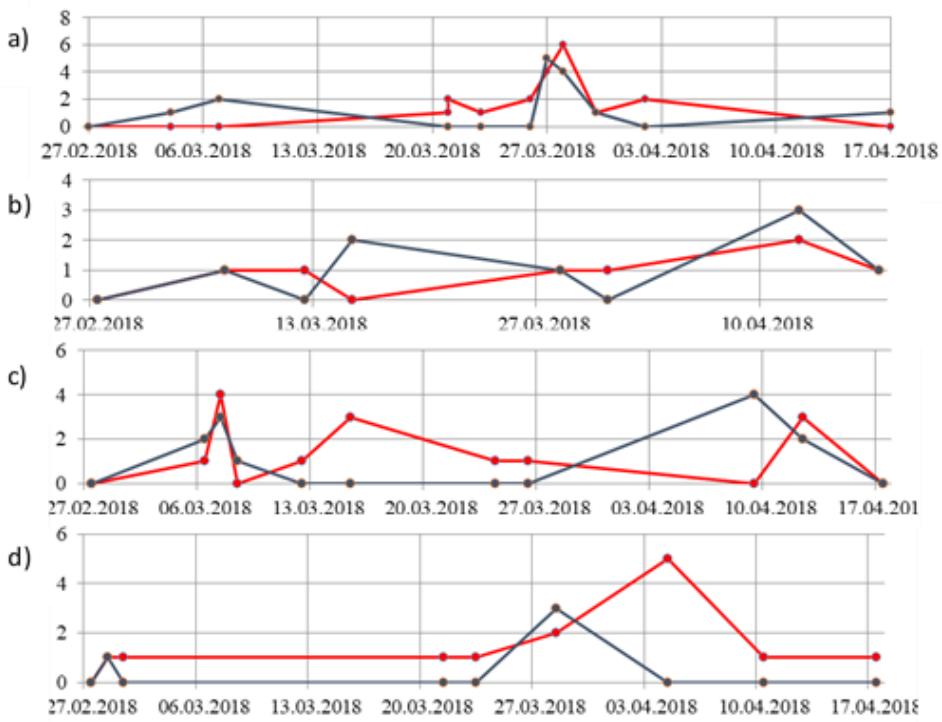

Fig. 1. Grahps of activity of students from 27.02.2018 to 17.04.2018 a.) uniform student work with increased activity in the middle of period b.) weekly user's activity c.) active work of the student at all stages d.) increased activity towards the end of the training period.

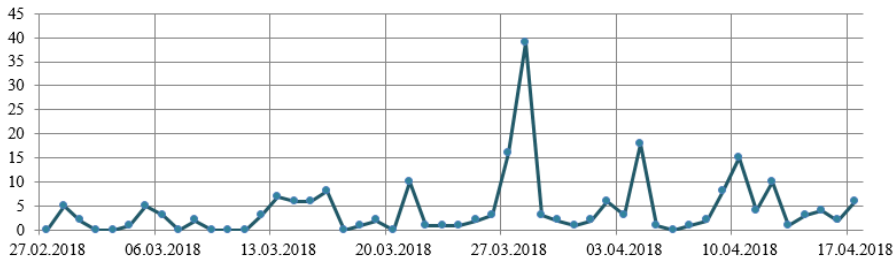

Fig. 2. Activity graph of educational group from 27.02.2018 to 17.04.2018.

The General graph clearly shows the increase in activity by the end of the first half-semester, as well as weekly before the next session. One of the main methods of

modeling seasonal and cyclic oscillations is a method based on the use of one – dimensional Fourier series. Frequency Fourier analysis was performed to confirm the assumptions. Calculations were performed using the program STATISTICA.

Periodic oscillations decomposed by the Fourier series are the sum of several sine and cosine harmonics with different periods:

$$y(t) = \sum_{k=1}^{\infty} (u_k \cos \omega_k t + v_k \sin \omega_k t) \tag{1}$$

u_k, υ_k – uncorrelated random variables with zero expectation and the same variance: $D(u_k) = D(v_k) = D_k$;

ω_k – the wavelength of the sine or cosine function, called the frequency.

The variance of the Fourier series is calculated by the formula:

$$D(y_t) = D\left[\sum_{k=0}^{\infty} u_k \cos(\omega_k t + v_k \sin\omega_k t\right] =$$

$$= \sum_{k=0}^{\infty} (\cos^2 \omega_k t + \sin^2 \omega_k t) D_k = \tag{2}$$

$$= \sum_{k=0}^{\infty} D_k$$

The dispersion of the Fourier series is the sum of all harmonics of its spectral decomposition [3].

The dispersion distribution of the Fourier series is graphically represented by a periodogram. The essence of the analysis of the periodogram is to determine the frequency or period with the highest spectral densities, which make the greatest contribution to the periodic oscillations of the time series, which will determine its main oscillation period.

The Fourier series of the form (1) can be considered as a linear model of multiple regression. The resulting variable in this model will be the values of the time series, and the independent variables will be the functions of the sinuses of all possible frequencies. The coefficients u_k for cosines and for sine υ_k will be the coefficients of the regression model, which show the degree to which the correlations of the corresponding functions with the original data. If the calculated value of the coefficient at a certain sine or cosine

is sufficiently large, then there is a strict periodicity at the corresponding frequency in the source data.

2 Research results

For the analysis, the data of the total activity of students were selected, as well as the special cases were analyzed. The graph of the constructed periodogram for the total activity (figure 3) shows a clear peak. Maximum – at a frequency of about 0.14 (day – 1). The calculated values of the periodogram can be seen in Table 1. Frequency is the number of cycles per unit of time. Thus, the frequency 0.14 (day – 1) corresponds to the value of 7.1428 period (the number of units of time required for a full cycle). It can be concluded that there is a clear 7 – day cycle of activity in the network. Also visible are clear peaks at frequencies 0, 27 (day – 1) and 0.40 (day – 1), indicating cycles of activity with a period of 2 and 3 weeks, respectively.

The example of an individual student (figure 4) is slightly different. According to Table 2, the highest frequency was 0.16(6) days – 1, which corresponds to a period of 6 days.

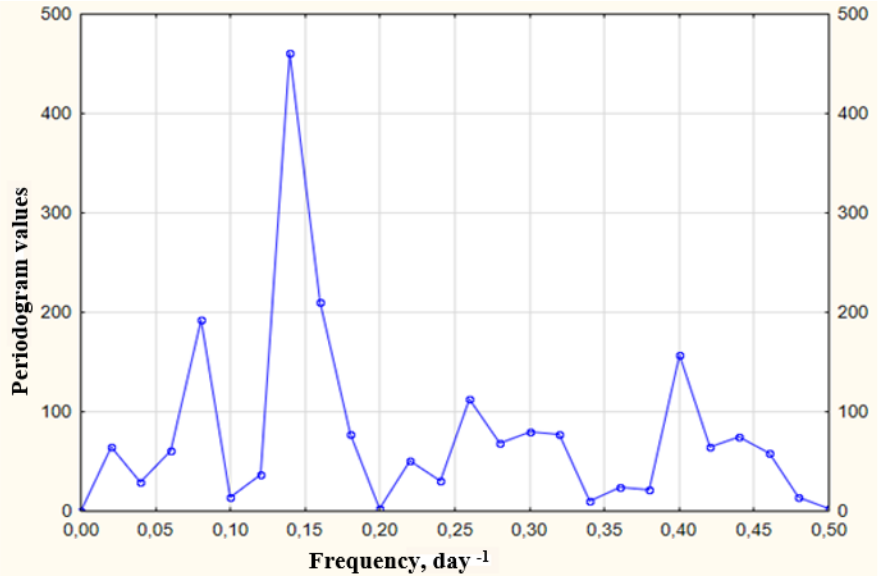

Fig. 3. Frequency analysis of a students' group activity (transactions)

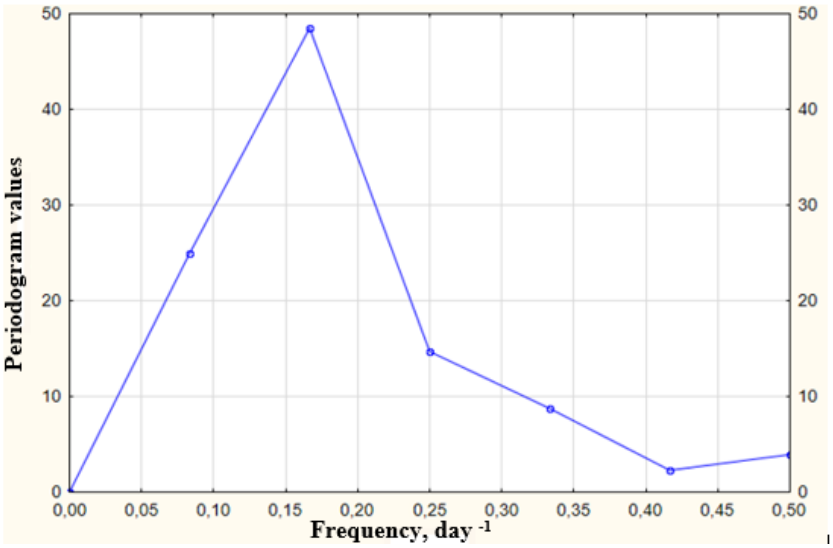

Fig. 4. Frequency analysis of a random student activity (transactions)

Table 1. Summary table of spectral analysis of the activity of the educational flow

Frequency	***Period***	***Periodogram value***
0,0	50,0	64,7
0,0	25,0	29,2
0,1	16,7	60,9
0,1	12,5	192,9
0,1	10,0	14,5
0,1	8,3	36,8
0,1	7,1	460,3
0,2	6,2	210,8
0,2	5,5	77,2
0,2	5,0	2,9
0,2	4,5	50,8
0,2	4,2	30,8
0,3	3,8	112,2
0,28	3,6	67,8
0,3	3,3	79,4
0,3	3,1	76,9
0,3	2,9	9,9
0,4	2,8	23,7
0,4	2,6	21,7

0,4	2,5	156,5
0,4	2,4	64,7
0,4	2,3	74,2
0,5	2,1	58,8
0,5	2,0	14,4
0,5	2,0	2,8

Table 2. Summary table of spectral analysis of individual student's activity

Frequency	***Period***	***Periodogram value***
0,1	12,0	24,9
0,2	6,0	48,5
0,2	4,0	14,7
0,3	3,0	8,8
0,4	2,4	2,2
0,5	2,0	3,9

Conclusion

The obtained calculations allow to propose an idea of the effectiveness of the using of EPS at the level of an individual teacher, student or group of students. It can be concluded that the generation of a report on the degree of involvement of students and teachers in the system is convenient. A clear 7 – day period of increasing activity in the performance of tasks by students was discovered.

All the actions performed by users in the EPS were analyzed in order to differentiate the actions of users in the course of different types of activities. Different classifiers for student and teacher were created.

This allows students to achieve the necessary level of activity for the successful completion of the semester, whereas teachers to assess the effectiveness of the work done by all participants in the educational process [4].

At the other hand, present experimental economics study of transactions' frequency in local community with autonomous financial instrument made it clear that in the interval of 2 – 50 days the most significant were transactions with periodicity of 6 – 7 and 12 days. Such periodicity reflects the week cycles of human activity in studies as well as in goods and services consumption. It can be expected to obtain the same periodicity in the real autonomous local communities.

Acknowledgements

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